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Geographic information systems compilation of geophysical, geologic, and tectonic data for the Bering Shelf, Chukchi Sea, Arctic margin, and adjacent landmasses

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ABSTRACT

The accompanying CD-ROM contains a compilation of geophysical, geologic, and tectonic data for the Bering Shelf, the Chukchi Sea, the Arctic margin, and adjacent landmasses. These data sets focus on Alaska, the Russian Far East, and the continental shelves that link these two landmasses. For compatibility with other available geographic information system (GIS) products, our GIS compilation extends from 120°E to 115°W, and from 40°N to 80°N. This area encompasses the region from the modern Pacific plate boundary of the Japan, Kurile, and Aleutian subduction zones, the Queen Charlotte transform fault, and the Cascadia subduction zone (in the south) to the continent-ocean transition from the Eurasian and North American continents to the Arctic Ocean (in the north); and from the diffuse Eurasian–North American plate boundary, including the probable Okhotsk plate (in the west) to the Alaskan-Canadian Cordilleran fold belt (in the east). The CD-ROM comprises thematic layers of spatial data sets for topography, gravity field, magnetic field, earthquakes, volcanoes, geology, tectonostratigraphic terranes, and cultural reference features, and also includes metadata (data about the data) for all these data sets. The spatial data sets can be viewed, analyzed, and plotted with commercial GIS software (ArcView and ARC/Info) or through a freeware program (ArcExplorer) that is included on this CD-ROM. This GIS compilation provides data for studies of the Mesozoic and Cenozoic collisional and accretionary tectonics that assembled this continental crust and of the neotectonics of active and passive plate margins in this region, and for constructing and interpreting geophysical, geologic, and tectonic models of the region.

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INTRODUCTION

In order to facilitate understanding of the tectonics of the geologically complex region between North America and Asia that includes Alaska and northeast Russia across the Bering Strait, we have assembled a geographic information systems (GIS) compilation of geological and geophysical data (Fig. 1). This region also presents difficulties for conventional and digital geographic mapping and for geologic mapping, in that the area includes Arctic regions, crosses longitude 180°, is partially marine, and straddles the United States/Russia political boundary. In Arctic latitudes the most common map projection (Mercator) introduces large distortions, so Polar and Lambert projections are often also used, creating the necessary but difficult ask of transforming data between projections. Many digital data sets are stored from 180°W to 180°E and some querying routines do not allow access of data sets straddling longitude 180°. Traditional geological tools allow us to map land areas, not marine areas, so that the geology of the submerged Bering and Chukchi continental shelves, extending more than 500 km offshore from mainland Alaska and Chukotka, is even less well known than that of Siberia, even though over most of this region the coastline is only an accidental manifestation of modern-day sea level rather than a fundamental geological boundary. The politicization of geologic maps leads us to commonly ignore the large part of the North American plate that is in Russia (the best geologic map of Alaska shows Russia as a white outline; the converse is true for the best geologic map of Russia). These four difficulties, i.e., variable projections, arbitrary longitude reference system, coastlines, and political boundaries, led us to create a GIS (Greninger et al., 1996) to facilitate our crustal studies of the Bering and Chukchi Seas, and adjacent onshore Alaska and Chukotka. That original GIS has been extended in the present compilation to the Circum–North Pacific area from 120°E to 115°W and from 40°N to 80°N to coincide with an earlier compilation, the Circum–North Pacific terrane map (Nokleberg et al., 1994a). The bulk of our digital data compilation has been made available as a U.S. Geological Survey (USGS) Open-File Report (Greninger et al., 1999), and is reprinted here with additions and corrections.

The map-making software most commonly used by academic geophysicists is probably Generic Mapping Tools (GMT) (Wessel and Smith, 1995) and the newer Interactive Generic Mapping Tools (iGMT) (Becker and Braun, 1998), both freeware packages that run on any Unix computer. GMT has been widely used to create images of superimposed point data sets (e.g., hypocenters) and raster data sets (e.g., topography), and many of the data sets it supports are common to this database (ETOPO5, GTOPO30, satellite-derived free-air gravity). GMT and iGMT are mapping, not GIS, software, so despite their widespread use we have chosen to develop a GIS compilation based on the Environmental Systems Research Institute (ESRI) ARC/Info and ArcView programs, for the following three reasons. (1) These programs permit database queries that are not available in GMT and iGMT. (2) We hope that use of ARC/Info and ArcView will encourage new, innovative ways of working with multiple geophysical and geological data sets such as geologic maps of the Russian Far East, Alaska, and the Canadian Cordillera. (3) Because ESRI software is available for both Windows and Unix computers, a greater opportunity exists for scientists in the former Soviet Union to have access to this GIS compilation.

We included data sets that we believe may assist geological and geophysical research, and that we are able to disseminate as digital data: topography, gravity field, magnetic field, earthquakes, volcanoes, geology, and tectonostratigraphic terranes, and sociopolitical fiducial information, though we have limited ourselves to data sets that can be fitted onto a single CD-ROM (640 Mb). The accompanying CD-ROM contains two separate products: (1) a compilation of data sets in ARC/Info format; and

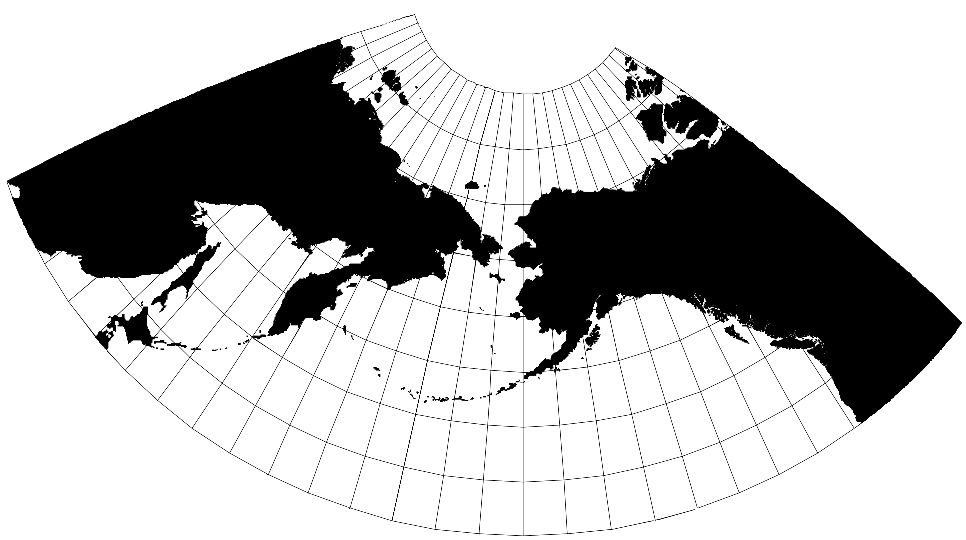

Figure 1. Location map showing full extent of geographic information system database. Few data sets cover entire region; extent of each data set is listed in metadata for that data set on the accompanying CD-ROM.

(2) a collection of displays (views) of combinations of these data sets in ArcView and ArcExplorer projects. The data sets in ARC/Info format are available to any GIS user for further manipulation and analysis, but it is beyond the scope of this chapter to provide a GIS tutorial: training is available online, e.g., through ESRI at http://campus.esri.com/campus/catalog/courses.cfm, and in readily available textbooks (e.g., ESRI, 1999; Hutchinson and Daniel, 2000). The ArcView and ArcExplorer projects can be used as displays for interpretation without any additional GIS manipulation. These projects include views to illustrate the type and quality of data available, and to illustrate some different ways in which data may be combined by utilizing the ability of GIS software to accept spatial queries.

The digital data consist of vector, raster, and point data. Vector data (e.g., the geographic base map) have a location precision that depends upon the scale of the original map and the density of the digitization points. Because of the large area covered, we have included no data sets or maps originally compiled at scales greater than 1:250 000, and some of our source data sets were compiled at scales as small as 1:10 000 000. Raster data (gridded data) have a resolution that depends upon the grid spacing and cell size. Our raster data sets range from <1 km to >8 km spacing. Point data (e.g., trackline shot locations or earthquake epicenter locations) are only limited by the precision of their locations.

All data sets are recorded in a Lambert azimuthal projection with a center of projection at 165°W, 70°N as originally utilized for the Circum–North Pacific terrane map (Nokleberg et al., 1994a) that forms the principal geologic base for our GIS compilation. Although it is common for digital data releases to be prepared as unprojected data, i.e., as data referenced to a geographic (latitude-longitude) coordinate system with no assigned map projection, all data sets in this GIS compilation are projected to a single chosen map projection in order to avoid problems associated with data sets that straddle longitude 180°. We do this so that this GIS compilation is accessible to scientists who lack proprietary GIS software and who use the freeware ArcExplorer provided on this CD-ROM. ArcExplorer displays our unprojected spatial data sets centered on the Greenwich, or zero meridian, split into separate far western and far eastern sections. Advanced users, i.e., those using programs such as ArcView or ARC/Info, have the option and ability to unproject and reproject the spatial data to a chosen projection. This procedure may lead to some loss of precision (due to a data conversion within ESRI software from double-precision to single-precision coordinates), but this loss of precision is not significant for data sets at scales of 1×10^6 and smaller. The geological and geophysical potential-field data sets on this CD-ROM are not intended for use at scales larger than 1:1 000 000.

All cartographic data sets for this GIS compilation are in ARC/Info coverage or GRID format. Various text files, including an explanatory README file, a detailed listing of all metadata (DOCUMENT), and detailed explanations to the Circum–North Pacific terrane map, are given in text (*.txt), Word 6 (*.doc), and Adobe Acrobat (*.pdf) formats. In addition, a suite of 178 stratigraphic columns for the Circum–North Pacific terrane map is provided in Adobe Acrobat format. The digital cartographic data for this compilation were compiled with ARC/Info 7.0.3 on a Sun Microsystems SPARC Station 20 computer running Solaris OpenWindows version 5.4 (Sun OS 2.4).

SYSTEM REQUIREMENTS

The data and text on this CD-ROM require a computer and software able to read ESRI data formats. Appropriate software packages include ARC/Info version 7.1.2 or higher, ArcView 3.1 or higher, and ArcExplorer. Full system requirements for each software package can be found at the Internet (Worldwide Web) homepage for ESRI, http://www.esri.com. In order to run ArcView 3.1, a Windows computer is required with a Pentium processor with 24 Mb of RAM (32 Mb recommended). A Pentium-II processor with a speed ≥200 MHz is recommended for handling the large data files. All systems require a color monitor that can display 256 colors. This CD-ROM was produced in accordance with the ISO 9660 and Macintosh HFS standards. All ASCII text on this CD-ROM file can be accessed from DOS, Windows, Macintosh, and Unix computers.

Instructions for installing the software on the disk, and complete details of the data contained on the disk, are found on the CD-ROM in the file /readme/document.***, in multiple file formats, text (*.txt), Word (*.doc), and portable document format (*.pdf).

GIS PROGRAMS FOR VIEWING OR MANIPULATING THESE DATA: ARC/INFO

ARC/Info is a full-featured GIS software program sold by Environmental Systems Research Institute, Inc. (ESRI), and is generally used on Unix-based workstations although it is also available for WindowsNT. (The separate software package PC ARC/Info is available for Windows (3.x, 95, 98, and NT), as well as DOS.) For the GIS compilation on this CD-ROM, the data are saved in ARC/Info 7.1.2, utilizing both coverage and GRID formats. ARC/Info can be utilized to view and manipulate the data sets on this CD-ROM exactly as compiled.

ArcView

ArcView (version 3.1) is a desktop GIS software program sold by Environmental Systems Research Institute, Inc. Although ArcView does not have all the features of ARC/Info, it is easier to learn; some recent ArcView extensions (e.g., 3D Analyst) are not available in ARC/Info 7.1.2. ArcView 3.1 runs on Unix computers and on Windows computers (3.x, 95, 98, or NT).

ArcExplorer

ArcExplorer is a freeware GIS-viewing program created by and available from Environmental Systems Research Institute, Inc. (ESRI) by download from http://www.esri.com. A copy is provided on this CD-ROM. The directory /norpac/setup/arcexplo contains installers for ArcExplorer 1.1 for Windows 95/98/NT. NT machines must have Service Pack 3 installed. In addition to viewing GIS data in ARC/Info, ArcView, and other digital formats, ArcExplorer permits GIS data queries. ArcExplorer is currently only available for Windows computers (95, 98, or NT 4.0). ArcExplorer can access the GIS data contained in ARC/Info 7.1.2 coverages on this CD-ROM. Because ArcExplorer cannot display gridded data sets, images of these data sets are created as ***.bil files, which are displayed for the following data sets: (1) two raster topographic data sets (/norpac/data/topogrfy/raster/etopo5 and /gtopo2); (2) three gravity data sets (/norpac/data/gravity/dgrav, /geosat, and /sea-surf); and (3) five magnetic data sets (/norpac/data/magnetic/ak_mag, /arct_mag, /asia_mag, /dnag_mag, and /russ_mag).

USE OF GIS COMPILATION ON UNIX, MACINTOSH, AND DOS/WINDOWS COMPUTERS

Depending on system configuration and user needs, the data can be viewed directly from the CD-ROM, or the data can be downloaded onto a computer hard drive for viewing, manipulation, and plotting.

Unix

To mount this CD-ROM on a Unix-based computer, become the root user, then: % su (not necessary for a Silicon Graphics workstation).

If a /cdrom directory does not exist, create one:
cd/
#mkdir cdrom

Use the command appropriate to the UnixTM host:

DG AViiON:	mount -o noversion,ro -t cdrom/<dev> /cdrom
DEC ALPHA:	mount -t cdfs -r -o nodefperm,noversion /<dev> /cdrom
DECstation:	mount -t cdfs -r -o nodefperfm /<dev> /cdrom
HP 700/8x7:	mount -rt cdfs /<dev> /cdrom (or use sam)
IBM RS/6000:	mount -v ‵cdrfs′ -p″ -r″ /<dev> /cdrom (or use smit)
Silicon Graphics:	mount -o setx -t iso9660 /dev/ssi/<dev> /cdrom
Sun Solaris 1.x:	mount -rt hsfs /<dev> /cdrom
Sun Solaris 2.3:	Use volume management software to mount and access the CD-ROM. Sun Workstations running the Common Desktop Environment will auto-mount the CD-ROM.

Macintosh

ArcView 3.1 and ArcExplorer are not available for the Macintosh computer. The document, Adobe Acrobat PDF, and readme files can be viewed, manipulated, and printed with a Macintosh computer. ArcView 3.0 for Macintosh can be used to create new ArcView project files.

DOS/Windows

To mount this CD-ROM on a DOS/Windows-based computer, insert the CD-ROM into a drive, and open the CD-ROM window. Follow the instructions in the next section.

OPENING THE DATA SETS AND EXAMPLES OF GIS COMPILATION

In the directory /norpac/setup, two ArcView projects (norpac1.apr, norpac2.apr) and one ArcExplorer project (norpac.aep) are provided to give users easy access to data on the CD-ROM. Note that norpac1.apr requires that Spatial Analyst, an ArcView Extension that allows advanced manipulation and analysis of raster or point data (such as aeromagnetic, gravity, and earthquake data) compiled in ARC/Info GRID format, be installed as well as ArcView 3.1. Use of norpac2.apr is designed for ArcView users who do not also have Spatial Analyst. Use of the ArcExplorer 1.1 file, norpac.aep, requires installation of the ArcExplorer program that is provided on the CD-ROM.

Use of GIS Compilation with ArcView 3.1

If ArcView 3.1 or higher is installed on your computer, do the following.

1. Place the CD-ROM in the CD Drive. Open the CD-ROM window.
2. Find the ArcView project setup.apr located in the directory /norpac/setup.
3. Open the ArcView project by clicking on setup.apr, either from a file manager or from within ArcView.
4. ArcView should start with a small window with the title, “Cannot find the NorPac Data” followed by the sentence, “Enter the location of the NorPac Data.” In the white box, replace “Drive Name” with the drive name and directory, “N:/norpac/” where “N” is the letter or name of the CD or hard drive. Next click “OK.” A new window will appear with the title, “Found Spatial Analyst!” followed by the sentence, “Select a Project to load.” In the white box, select either “Norpac1.apr (Spatial Analyst),” if your computer has both ArcView 3.1 and Spatial Analyst installed, or “Norpac2.apr (non-Spatial Analyst),” if your computer has only ArcView 3.1 installed. The selected ArcView project should load automatically. (Note that if Spatial Analyst is not installed, Norpac2.apr will automatically load.) A window will appear with the title norpac1.apr or norpac2.apr, depending on the preceding selection. In the white box on the left side of the window will be a list of views that can be opened, viewed, manipulated, or printed within ArcView. Each view is a digital map of part of the GIS compilation. Each view has one or more themes (layers) that can be selected (made visible) or deselected (made invisible).

The views are: Active Earth Example; Magnetic—Lithologic Correlation Example; Topographic Example; Cultural Features; Geology—Alaska; Geology—Bering-Chukchi shelves; Geology—Russia; Gravity—DGRAV; Gravity—Geosat; Gravity—Seasurface; Magnetics—Alaska; Magnetics—Arctic; Magnetics—DNAG; Magnetics—East Asia; Magnetics—Russia; Reflection Profile Tracklines; Seismicity; Terranes—Alaska; Terranes—Canadian Cordillera; Terranes—Circum–North Pacific; Topography—Raster; Topography—Vector; and Volcanoes—Active.

A more detailed description of these views, including the theme name of each layer shown on screen, the relevant data set location, and legend location, is contained on the CD-ROM in the file /readme/document.***, in the section on Description of Views. Note that if new themes and views are added to either norpac1.apr or to norpac2.apr and the ArcView project is saved, the ArcView project file needs to be edited before subsequent use of setup.apr. Using a text editor such as WordPad, the path name N:/norpac/ (where N is the designator of the CD drive) in either norpac1.apr or norpac2.apr (as appropriate) will need to be replaced by $norpac/.

Use of GIS Compilation with ArcExplorer 1.1

If ArcExplorer 1.1 is installed on your computer:

1. Place the CD-ROM in the CD Drive. Open the CD-ROM window.
2. Find the ArcView project "norpac.aep" located in the directory /norpac/setup.
3. Copy the ArcExplorer project, "norpac.aep" into a directory on your hard drive. Deselect the Read-only box for the properties of this file. In order to accomplish this on a Windows computer, right-click on the file name and select "Properties."
4. Open the norpac.aep file in a word processor program, such as WordPad. Substitute the text string, D:\norpac\ with N:\norpac\ where "N" is the letter or name of the CD drive. Save the file as a text file with a new file name. Note that a back slash (\) is used in the substitution**.**
5. Start the ArcExplorer project by clicking on the new file name. The ArcExplorer project will start. In the gray box on the left side will be a list of preselected themes that can be opened (by selecting), viewed, and printed. Each theme is one part of the GIS compilation. A full list of the theme names and their "translated" names is on the CD-ROM in the file /readme/document.***.

DIRECTORY ORGANIZATION

The /norpac directory of this CD-ROM contains four directories, /data, /readme, and /setup (Table 1), plus the /index directory used for Acrobat Search. All directory and subdirectory names are restricted to eight lowercase characters for the benefit of DOS users. In all tables the directories and subdirectories are

TABLE 1. DIRECTORY ORGANIZATION WITHIN /norpac

Directory	Description of files
data	GIS data in ARC/Info 7.1.2 and GRID formats. Data directories are organized by data type in the following subdirectories: cultural, geology, gravity, magnetic, seismcty, shiptrax, terranes, topogrfy, and volcano. Each of these contains a subdirectory for each data set, which in turn contains all necessary files for use of the data with ESRI Arc software. All the vector data sets are presented as ARC/Info coverages accessible by ArcView and ARC/Info. Because Arc/Info GRID format files are not accessible by ArcExplorer, these data sets are represented as ***.bil images that can be opened in ArcExplorer. Subdirectories within geology, seismcty, and terranes also contain explanatory texts and figures, in ***.txt, ***.doc, and ***.pdf formats, within sub-subdirectories called /explanat. All data directories act as ARC/Info workspaces and include an ARC/Info file. Two additional subdirectories exist. The directory /norpac/data/examples contains shape files for new coverages created from this CD-ROM that are used to produce example views of data compilations. The directory /norpac/data/legends contains suggested color tables and legends for different data sets. The directories /examples and /legends are not ARC/Info workspaces and have no ARC/Info files.
readme	Information for this CD-ROM in multiple file formats, text (***.txt), Word (***.doc), and portable document format (***.pdf). ***pdf files can be read with Adobe Acrobat Reader 4.0, freeware contained in /norpac/setup/Acrobat. readme.*** contains brief ASCII information about the CD-ROM. document.*** (this file) contains full documentation for all data sets on this CD-ROM. Subdirectory cpyright contains copyright notices associated with multiple-generation data.
setup	Installation files for ArcExplorer, the freeware software for users of this CD-ROM who lack access to the proprietary ArcView and ARC/Info GIS software. The files are contained in the subdirectory /norpac/setup/explorer. Files for Acrobat, freeware text-viewing software for PDF files, are contained in the subdirectory /norpac/setup/Acrobat. Project files for use with ArcView (norpac1.apr for users with the extension Spatial Analyst installed, norpac2.apr for those without) and for use with ArcExplorer (norpac.aep).

listed alphabetically. However, the ArcView windows with the available views for the projects norpac#.apr are listed alphabetically by "theme name," as listed in the contents of /data.

In the following sections we discuss the directories data, readme, and setup, and then the subdirectory /data/examples. Complete data about the data sets (metadata files) are on the CD-ROM in the files /readme/document.***, in multiple file formats, text (*.txt), Word (*.doc), and portable document format (*.pdf). These metadata listings contain the following information for each data set, to the extent available: the data type; the data set geographic extent, projection, source scale, or source grid interval; the data range (maximum and minimum values), resolution, and/or error estimates; a data dictionary of arc, polygon, and point attributes; data documentation files and data legends available on the CD-ROM; and the primary reference to, and any further information available about, the data set.

CONTENTS AND DESCRIPTION OF /norpac/setup

The directory /norpac/setup contains subdirectories /explorer and /Acrobat, which hold the freeware programs ArcExplorer and Adobe Acrobat, respectively.

The directory /norpac/setup/Acrobat contains installers for Adobe Acrobat Reader 3.01 and 4.0 for both Windows 95/98/NT and Macintosh. The latest version of Adobe Acrobat Reader can also be downloaded free via the Internet from the Adobe homepage on the Worldwide Web at http://www.adobe.com.

The directory /norpac/setup also contains the files norpac .aep, norpac1.apr, and norpac2.apr. The ***.aep and ***.apr files are project files for ArcExplorer and ArcView, respectively. If either ArcView and/or ArcExplorer are installed, the ***.apr and ***.aep files can be loaded from within these programs, using the instructions given in the preceding section on opening the data sets, to display preset examples of the data. In general, users need not modify these files, but will wish to create new project files for individual needs.

CONTENTS AND DESCRIPTION OF /norpac/data

For a complete list of the available data sets, see Table 2.

CONTENTS AND DESCRIPTION OF /data/examples

Example compilations (coverages) of individual data sets (themes) from this GIS

In order to display some features (and limitations) of the available data sets, and to illustrate some ways in which our GIS compilation might stimulate data analysis, we have created three example "views" of various combinations of data sets using ArcView or ArcExplorer projects. Our "Topography" example (Fig. 2) shows the different resolution raster and vector data available for different subareas, and highlights both the range of data availability and also data problems for a single data type. Our "Active Earth" example (Fig. 3) combines tectonic information (faults, volcanoes, earthquake locations) with topographic and gravity data to show the relationship between these features and to synthesize the neotectonic activity of our region. Our "Magnetic-Lithologic Correlation" example (Fig. 4) overlays lithologic data on aeromagnetic data onshore, suggesting a correlation between high-frequency magnetic signature and igneous rocks that may then allow recognition of different geologic provinces offshore. These three views are only a few examples of many possible visualizations of combinations of the spatial data in this GIS compilation. For all three examples, the CD-ROM contains specific views and color scales that highlight features of interest. Users are encouraged to experiment with their own views, to zoom into different areas, and to select different display styles, in order to emphasize different features and to portray different and new geological relationships.

"Topography" example, /data/examples/topog_ex (Figure 2)

Table 3 lists the data sets that are superimposed in the "Topography" example view (Fig. 2); the higher-numbered layers are above and partly concealing the lower-numbered layers. Topography, i.e., the departure of the land and seafloor elevation from sea level, is the most basic geophysical data set, yet data availability and data quality vary widely. The coverages in this example (Fig. 2) have been chosen to show the range of different topographic data sets publicly available, both raster and vector, and land and marine, and to focus on typical data quality and reliability issues.

In the "Topography" example, the base layer is low-resolution (1:10 M) vector bathymetry with contours at 1000 m intervals, plus the −200 m isobath. Its land areas are obscured by layer 2, the best raster topography available globally, GTOPO30. This nominal 30 arc-second topography has points at ca. 900 m spacing, corresponding to a vector map on a scale of ~1:1 M (on which this raster data set would provide a data point every 0.25 mm). GTOPO30 has superimposed on it low-resolution drainages for geographic reference (layer 3), and more important, the contour lines (layer 4) from the low-resolution basal layer. Layers 1 and 4 are the same data set displayed with different legends, the former with color-shaded bathymetry (using the same legend as layers 5, 6, and 7), the latter with line contours only and no shading. Comparison of these contour lines with the raster GTOPO30 shows how the low-resolution contour data generalize the more detailed raster data. In general the contours match well with, but are obviously a generalization of, the raster topography; e.g., the narrow drainages dissecting the south flank of the Brooks Range are visible in the raster data (the chosen color scale emphasizes the change from the 200 m contour by a change from green to very pale green), but not in the 200 m contour line.

TABLE 2. DATA SETS CONTAINED WITHIN /norpac/data

Data directory	Subdirectory	File name (data set name) in GIS	Theme name used in views presented in projects norpac1.apr and norpac2.apr	Brief description of data and references
cultural		boundary	International/state boundaries	International, provincial, and state boundaries (ESRI's ArcWorld database, http://www.esri.com)
		cities	Cities	Significant population centers (ESRI's ArcWorld database, http://www.esri.com)
		features	Manmade features	Other sociocultural features, such as airports and golf courses (ESRI's ArcWorld database, http://www.esri.com)
		latlong5	Latitude/longitude grid (5°)	Latitude and longitude grid at 5° spacing (ESRI's ArcWorld database, http://www.esri.com)
		latlon12	Latitude/longitude grid (12°)	Latitude and longitude grid at 12° spacing (ESRI′s ArcWorld database, http://www.esri.com)
examples				Shape files used in constructing the example views. "Topography," "Active Earth," and "Magnetic-Lithologic correlation" examples are discussed in text
geology	onshore	ak_geol	Geologic map of Alaska	Geologic map of Alaska (Beikman, 1980)
		rus_flts	Fault map of Russia	Fault map of Russia (Nalivkin, 1994; GlavNIVC, 1998)
		rus_geol	Geologic map of Russia	Geologic map of Russia (Nalivkin, 1994; GlavNIVC 1998)
	offshore	isopachs	Sedimentary basin isopachs, Bering-Chukchi shelves	1-km isopachs in selected Mesozoic and Cenozoic basins (Plate 1; Miller et al., this volume; Preface)
		basnflts	Intrabasin faults, Bering-Chukchi shelves	Faults within selected Mesozoic and Cenozoic basins (Plate 1; Miller et al., this volume; Preface)
		dredge	Dredge samples from the Beringian margin	Lithology of dredge samples from the Beringian margin (Plate 1; Miller et al., this volume; Preface)
		wells	Exploration wells, Bering-Chukchi shelves	Summary information for selected exploration wells (Plate 1; Miller et al., this volume; Preface)
gravity		dgrav	Onshore Bouguer and offshore free-air gravity (mGal)	Onshore Bouguer gravity anomalies and offshore free-air gravity anomalies; dgrav.bil has been created† (Hittelman, 1994; Committee for the Gravity Anomaly Map of North America, 1987)
		geosat	Satellite free-air gravity (mGal)	Satellite-derived free-air gravity, offshore areas only; geosat.bil has been created† (Smith and Sandwell, 1997)
		sea_surf	Satellite sea-surface height (m)	Satellite-derived sea-surface heights; sea_surf.bil has been created† (Hittelman, 1994)
legends				Contains suggested color-bars and contour information for each data set as ***.avl files; automatically accessed by ArcView as needed; contains subdirectories for each of the other subdirectories to /norpac/data (i.e., cultural, geology, gravity, etc.)

(continued)

TABLE 2. DATA SETS CONTAINED WITHIN /norpac/data (continued)

Data directory	Subdirectory	File name (data set name) in GIS	Theme name used in views presented in projects norpac1.apr and norpac2.apr	Brief description of data and references
magnetic		ak_mag	Magnetic map of Alaska (nT)	Magnetic map of Alaska (mainly onshore); ak_mag.bil has been created† (Saltus and Simmons, 1997)
		arct_mag	Magnetic map of the Arctic (nT)	Magnetic map of the Arctic (largely offshore); arct_mag.bil has been created† (Verhoef et al., 1996; Macnab et al., 1995)
		asia_mag	Magnetic map of Far East Asia (nT)	Magnetic map of Far East Asia; asia_mag.bil has been created† (Geological Survey of Japan and CCOP, 1996)
		dnag_mag	Magnetic map of North America (nT)	Magnetic map of North America, onshore and offshore; dnag_mag.bil has been created† (Committee for the Magnetic Anomaly Map of North America, 1987; Hittelman et al., 1989)
		russ_mag	Magnetic map of Russia (nT)	Magnetic map of Russia; russ_mag.bil has been created† (Anonymous, 1995)
seismcty		isc_cat	Global seismicity, 1964–1991	Catalog of global seismicity, 1964–1991 (Whiteside et al., 1996)
		ak_seis	Alaskan seismicity, 1898–1998	Alaska State seismicity, 1898–1998 (Hansen et al., 1999)
		chukseis	Chukotka and western Bering Sea seismicity	Catalog of Chukotka and western Bering Sea seismicity (Fujita et al., this volume and 2001)
shiptrax		ew94_09	Ship trackline, EW94-09	Ship trackline for geophysical cruise EW94-09 (Fliedner and Klemperer, 1999; Holbrook et al., 1999)
		ew94_10	Ship trackline, EW94-10	Ship trackline for geophysical cruise EW94-10 (Brocher et al., 1995; Klemperer et al., this volume, Chapter 1)
terranes	alaska	explanat		ak_terr.*** (map explanations)
		terr_lnd	Alaska terrane map, 1:2.5M	Tectonostratigraphic terrane and overlap map of Alaska (scale, 1:2.5M) (Nokleberg et al., 1994b)
	canada	assemblg	Canadian Cordillera—terranes/ tectonic assemblages	Terrane and tectonic-assemblage maps of the Canadian Cordillera; hotlinks have been created†† (Journeay and Williams, 1995)
	nor_pac		Circum–North Pacific Terrane Map	Circum-North Pacific Tectonostratigraphic Terrane Map; hotlinks have been created†† (Nokleberg et al., 1994a)
		basins	Circum–North Pacific basins	Outlines of Mesozoic and Cenozoic basins
		coast	Circum–North Pacific coastline	Coastline; same as topogrfy/vector/contours, but presented as sea-level contour only
		explanat		assemb (text files for assemblage descriptions; columns (stratigraphic columns); terranes (text files for terrane descriptions); terrane.*** (map explanation)
		flts_lnd	Circum–North Pacific onshore faults	Onshore faults
		flts_ocn	Circum–North Pacific offshore faults	Offshore faults
		flts_pos	Circum–North Pacific post-accretionary faults	Post-accretionary faults, onshore and offshore
		mag_lins	Circum–North Pacific magnetic lineaments	Magnetic lineaments

		ocn_geol	Circum–North Pacific oceanic geology	Oceanic geology
		sea_mnts	Circum–North Pacific seamounts	Seamounts
		terr_lnd	Circum–North Pacific onshore terranes—terranes/overlap abbreviations/overlap assemblages	Onshore terranes
		terr_ocn	Circum–North Pacific offshore terranes	Offshore terranes (Nokleberg et al., 1994a)
topogrfy	raster			raster contains gridded topographic data
		etopo5	5′ topography/bathymetry (m)	5′-sampled land topography and marine bathymetry; etopo5.bil has been created[†] (Hittelman et al., 1994; NOAA, 1988)
		gtopo2	2′ topography/bathymetry (m)	2′-sampled land topography and marine bathymetry (only available to 70°N); gtopo2.bil has been created[†] (Smith and Sandwell, 1997)
		gtopo30	30″ land topography (m)	30″-sampled topography (land only) (U.S. Geological Survey, 1997)
		hillshad	hillshade of 30″ land topography	30″-sampled topography illuminated by sun from 315° at 45° elevation
	vector			vector contains contours (elevation or bathymetry) and hence polygons lying between fixed contour values (Alaska Biological Science Center, 1998)
		ak_shelf	U.S. shelf bathymetry (m) (1:0.25M)	Bathymetry for U.S. waters shallower than 200 m, Beaufort Sea to the Aleutians (most detailed, 1:0.25M)
		ber_chuk	Bering/Chukchi Seas bathymetry (m) (1:2.5M)	Bathymetry for Bering and Chukchi Seas, U.S. and Russian waters (intermediate detail, 1:2.5M)
		chukchi	Chukchi Sea/Bering Straits bathymetry (m) (1:1M)	Bathymetry for Chukchi Sea and Bering Straits, U.S. and Russian waters (more detailed, 1:1M)
		nor_pac	1:10M topography /bathymetry (m)	Circum–North Pacific topography and bathymetry (least detailed, 1:10M)
		rivers	Rivers	Major drainages, circum–North Pacific (Moore, 1990; Nokleberg et al., 1994a)
		shorline	World Vector Shoreline (1:0.25M)	World Vector Shoreline, designed for use at scales of up to 1:250 000 (http://web.ngdc.noaa.gov/mgg/fliers/93mgg01.html)
volcano		volcano	Volcanoes	Historically active volcanoes (Simkin & Siebert, 1994; Simkin et al., 1994)

[†] For some gridded data sets, an image file, /data/data-directory/data-subdirectory/filename.bil, is created to allow viewing of these data sets in the freeware ArcExplorer program, which otherwise cannot display these data sets.

[††] For some data sets, hotlinks are created to link features in views to other data sources, typically text descriptions of geologic units. When the linked feature is clicked with the Hot Link tool, ArcView opens the linked data source. Hotlinks are created for the map explanations for the Circum-North Pacific tectonostratigraphic terrane map and for the terrane and tectonic assemblage maps of the Canadian Cordilleran. Refer to ArcView manuals for use of the Hot Link tool.

Layers 5, 6, and 7 of the "Topography" example are successively more detailed bathymetric coverages (1:2.5 M; 1:1 M; 1:0.25 M, respectively) (cf. layers 1 and 4, 1:10 M), each data set encompassing a successively smaller area (Bering and Chukchi Seas; Chukchi Sea and Bering Straits; U.S. continental shelf [waters shallower than 200 m]) (cf. layer 1, with full coverage). Depth resolution increases correspondingly, from 1000 m throughout (layer 1), to 10 m in shallow water to 1000 m in deep water (layer 5), to 10 m throughout (layer 7). An identical color bar has been chosen to shade layers 1, 5, 6, and 7, so that the boundaries between the data sets are only visible where dense contours give way to sparse contours, and due to a thin outline drawn for each layer. The nesting of these four layers shows clearly how topographic resolution increases in countries rich enough to be rich in data (U.S. waters) and in shallow, nearshore waters. The uppermost of these bathymetric layers is used to illustrate a typical problem with digital data sets used uncritically. There are some coastal regions of shallow tidal waters for which topogrfy/vector/ak_shelf lacks data (so-called "holiday areas" in which no data were collected). The polygons are attributed with the elevation value +999, in contrast to the true but unknown negative value. When shaded uncritically, these areas may appear as land in a display (e.g., see the proximal regions of the Yukon Delta entering into Norton Sound which in reality have depths of –9 to –1 m, but are coded as positive values and shaded light green by the legend legends/topog_ex/ak_shelf.avl).

The relative agreement of different data sets is tested by comparing their coastlines with generally excellent results. With reference to the World Vector Shoreline, the 0 m (sea-level) contour derived from GTOPO30 is consistent to within 1 pixel (900 m) at Saint Lawrence Island in the approximate center of our coverages (Fig. 2). Note that although GTOPO30 is sampled at a 30 arc-second interval, in some areas this represents an oversampling of originally coarser data. This oversampling is interpreted as the cause of some artifacts, e.g., sharp boundaries in the elevation samples, both north-south and east-west, bounding the northern promontory of the Seward Peninsula. Athough barely visible in this "Topography" example, these artifacts are clearly seen in the "Active Earth" example. A complete 1-km-sampled digital elevation model of land areas of the Earth (NOAA's Global Land One-kilometer Base Elevation [GLOBE] Project) is under development at http://web.ngdc.noaa.gov/seg/topo/globe.html.

With respect to the World Vector Shoreline, the vector coverage topogrfy/vector/nor_pac (layers 1 and 4 in "Topography" example) is offset by 0–4 km around Saint Lawrence Island, appears consistent around Kamchatka, is displaced ~8 km north near Barrow, and is displaced ~4 km southwest near Anchorage (Fig. 2). We believe that these errors arose during the process of hand-tracing the coastline from the 1:10 M paper map (Moore, 1990) onto mylar, followed by scanning: a 1 mm error at the 1:10 M scale results in 10 km of relative displacement. Displacements of these magnitudes should also be anticipated in the other coverages of the Circum–North Pacific terrane map, and represent the limits of useful accuracy in our database. Other errors are present in topogrfy/vector/nor_pac: several islands are missing (including both the Diomede Islands and even Nunivak, ~50 000 km^2!; Fig. 2). We do not know if similar errors are present in the Russian waters that are not known to us personally. At least a few polygons are miscoded (see the closed contour and apparent landmass east of the Shumagin Islands, highlighted in bright yellow in Fig. 2 by the legend legends/topog_ex/n_p_eror.avl designed for this purpose). The higher-resolution vector coverages (topogrfy/vector/ak_shelf, topogrfy/vector/chukchi, and topogrfy/vector/ber_chuk) all appear to be consistent with the World Vector Shoreline. Although not shown here, the Canadian terrane map terranes/canada/assemblg appears to be very well correlated with the World Vector Shoreline, and the Alaska terrane map terranes/alaska/terr_lnd seems to be offset by only ~3 km to the southwest, an error probably acquired during hand-digitization from a Decade of North American Geology (DNAG) map with its center of projection at ~100°W, well outside the present coverage.

Layers 8 and 9, ship tracks, are included in the "Topography" example as a visual centerpiece and because an original in-

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Figure 2. Topography of Bering Shelf–Chukchi Sea and adjacent landmasses superimposed with tracklines of geophysical cruises discussed by Klemperer et al. (Chapter 1, this volume). Depths and elevations not specified in legend are shown by intermediate shades of greens and blues. See text for description of data sets shown, and discussion of potential pitfalls with compiled data sets, including holiday areas and miscoded polygons. A is Anchorage; B is Barrow; D is Diomede Islands; Nv is Nunivak Island; S is Shumagin Islands; St.L is Saint Lawrence Island. Image is on CD-ROM at /norpac/data/examples/topog_ex.

Figure 3. Free-air gravity of Bering Shelf–Chukchi Sea and relief of adjacent landmasses (sun shaded with sun angle of 45° elevation from northwest) superimposed with earthquake locations (color coded by depth; size of symbol corresponds to magnitude), Holocene volcanoes, and faults. See text for description of data sets shown. H is Hagemeister Island; K is Kaltag fault; St.M is Saint Matthew Island; T is Togiak-Tikchik strand of Denali fault and Togiak Lake; Z is Zemchug Canyon. Image is on CD-ROM at /norpac/data/examples/act_erth.

Figure 4. Magnetic anomalies of Bering Shelf–Chukchi Sea and adjacent landmasses superimposed with outline geological maps of Russia and Alaska. Because the four different magnetic data sets shown have not been merged, four different legends have been defined in which identical colors correspond to identical ranges of standard deviations away from the specific data mean, in order to minimize offsets in the dichromatic red-blue color scale where different data sets abut. Igneous (volcanic, plutonic, ultramafic) units are tinted yellow. See text for description of data sets shown. An is Anadyr basin; G is Goodnews arch; M-H is Matthew-Hall basin; Nav is Navarin basin; Nv is Nunivak Island; Pb is Pribilof Islands; St.G is Saint George basin; St.M is Saint Matthew Island. Corresponding image on CD-ROM at /norpac/data/examples/mag_lith has the additional feature that the gray and yellow shading, distinguishing igneous and nonigneous rocks, is transparent, allowing correlation of magnetic features from onshore to offshore. This transparency is not preserved in this figure printed from a JPEG file.

TABLE 3. DATA SETS DISPLAYED IN "TOPOGRAPHY" EXAMPLE

	Data set location	Legend location in /norpac/data/legends/topog_ex (locations of the form ***2.avl are for use with norpac2.apr)	Data description
10	cultural/latlong5	latlong5.avl	Latitude and longitude grid at 5° spacing
9	shiptrax/ew94_09	ew94_09.avl	Ship trackline for geophysical cruise EW94-09
8	shiptrax/ew94_10	ew94_10.avl	Ship trackline for geophysical cruise EW94-10
7	topogrfy/vector/ak_shelf	ak_shelf.avl (ak_shelf2.avl)	Bathymetry for U.S. waters shallower than 200 m, Beaufort Sea to the Aleutians (1:250 000)
6	topogrfy/vector/chukchi	topovect.avl (topovect2.avl)	Bathymetry for Chukchi Sea and Bering Straits, U.S. and Russian waters (1:1 000 000)
5	topogrfy/vector/ber_chuk	topovect.avl (topovect2.avl)	Bathymetry for Bering and Chukchi Seas, U.S. and Russian waters (1:2 500 000)
4	topogrfy/vector/nor_pac	n_p_eror.avl (n_p_eror2.avl)	Circum–North Pacific region (1:10 000 000), as topographic contours and a single polygon coded in error (see text)
3	topogrfy/vector/rivers	rivers.avl	Major drainages, circum–North Pacific region
2	topogrfy/raster/gtopo30	gtopo30.avl	30″-sampled land topography, color-shaded topography
1	topogrfy/vector/nor_pac	topovect.avl (topovect2.avl)	Circum–North Pacific region (1:10 000 000), color-shaded bathymetry

tent of this GIS database was to support interpretations of seismic profiles acquired along these tracklines.

"Active Earth" example, /data/examples/act_erth (Figure 3)

Table 4 lists the data sets that are superimposed in this view; the higher-numbered layers are above and partly concealing the lower-numbered layers. These data sets were chosen to show how a map can be created from our GIS database to illustrate the relations between active seismicity, mapped faults, volcanoes, and topography. This view illustrates the neotectonic setting of the study area.

Although topography is the most basic data set for studying tectonics, because marine bathymetry is shown in the "Topography" example, for the base layer in this example we display the satellite-derived free-air gravity, /gravity/geosat, using a standard blue-to-red dichromatic color bar (blue represents gravity lows; red represents gravity highs). These data constitute a topographic proxy in marine areas. On land the GTOPO30 data set is used, as in the "Topography" example, and because the marine gravity data set had its land areas masked using the nor_pac coastline, the offset between nor_pac and GTOPO30 appears as an offset, or doubled, coastline wherever the nor_pac coastline is outside (seaward of) the GTOPO30 coastline. This double coastline, e.g., adjacent to northern Alaska, represents the discrepancy between the nor_pac coastline and the GTOPO30 coastline, rather than a discrepancy between nor_pac and /gravity/geosat.

Subsurface density variations are important to the gravity field, but the most significant features are the major changes in water depth at the Aleutian trench, and across the Beringian margin and the Arctic shelf edge, as made clear by the superimposition of the second layer, bathymetric contours from /topogrfy/vector/nor_pac. Abrupt bathymetric features correspond well with corresponding features of the gravity field, e.g., the topographic promontory of the Bering Shelf edge, just west of Zemchug Canyon (Fig. 3).

For layer 3, rather than simply repeat the color-scale bar used for the GTOPO30 layer in the "Topography" example, a hillshade is applied to provide a real sense of the topography. The hillshade was created using the ESRI Spatial Analyst (ARC GRID has an equivalent program) with a sun angle of 45° elevation from the northwest. This sun angle highlights the data errors in GTOPO30 on the northern Seward Peninsula (Fig. 3) (described in "Topography" example), and highlights (as dark lineaments) the topographic lineaments and valleys corresponding to the southwest-northeast family of faults that transect southern and western Alaska.

Earthquake epicenters are overlaid as seven different themes from the International Seismological Centre (ISC) catalog, /seismcty/isc_cat. In order to capture both the depth and magnitude information on a single view, seven subsets of the catalog are derived corresponding to magnitude ranges of one-half unit, from 3.5 ≤ magnitude < 4.0 to magnitude ≥ 6.5. The earthquakes of each magnitude range are displayed with a different-size circle, and these symbols are color coded by hypocentral depth (dichromatic yellow to blue representing shallow to deep sources). This color variation clearly shows the northward dip of the Benioff zone beneath the Alaskan Peninsula and the Aleutian Islands (Fig. 3). There is no easy way to use the focal mechanism of individual earthquakes as an individual symbol within ArcView, so focal-plane solutions are not included in the database. However, solutions for individual earthquakes are readily available, e.g., from the Harvard centroid-moment tensor (CMT) catalog at http://www.seismology.harvard.edu/CMTsearch.html.

Coverages of volcano and fault locations complete this example. The volcanoes (black spots on red circles, Fig. 3) show

TABLE 4. DATA SETS DISPLAYED IN "ACTIVE EARTH" EXAMPLE

	Data set location	Legend location in /norpac/data/legends/act_erth	Data description
14	terranes/nor_pac/flts_pos	flts.avl	Postaccretionary faults, onshore and offshore onshore faults
13	terranes/nor_pac/flts_lnd	flts.avl	Onshore faults
12	terranes/nor_pac/flts_ocn	flts.avl	Offshore faults
11	volcano	volcano.avl	Volcanoes active during the Holocene
10	examples/mag35 derived from seismcty/isc_cat	mag35.avl	Earthquakes of 3.5 ≤ magnitude < 4.0, extracted from Catalog of Global Seismicity, 1964–1991
9	examples/mag40 derived from seismcty/isc_cat	mag40.avl	Earthquakes of 4.0 ≤ magnitude < 4.5, extracted from Catalog of Global Seismicity, 1964–1991
8	examples/mag45 derived from seismcty/isc_cat	mag45.avl	Earthquakes of 4.5 ≤ magnitude < 5.0, extracted from Catalog of Global Seismicity, 1964–1991
7	examples/mag50 derived from seismcty/isc_cat	mag50.avl	Earthquakes of 5.0 ≤ magnitude < 5.5, extracted from Catalog of Global Seismicity, 1964–1991
6	examples/mag55 derived from seismcty/isc_cat	mag55.avl	Earthquakes of 5.5 ≤ magnitude < 6.0, extracted from Catalog of Global Seismicity, 1964–1991
5	examples/mag60 derived from seismcty/isc_cat	mag60.avl	Earthquakes of 6.0 ≤ magnitude < 6.5, extracted from Catalog of Global Seismicity, 1964–1991
4	examples/mag65 derived from seismcty/isc_cat	mag65.avl	Earthquakes of magnitude ≥ 6.5, extracted from Catalog of Global Seismicity, 1964–1991
3	topogrfy/raster/hillshad	hillshad.avl	Hillshade derived from 30″-sampled land topography illuminated by sun from 315° at 45° elevation
2	topogrfy/vector/nor_pac	nor_pac.avl	Circum–North Pacific region (1:10 000 000)
1	gravity/geosat	geosat.avl	Satellite-derived free-air gravity, offshore areas only

not only the Pacific Ring of Fire, but also the young centers of the Bering Strait basaltic province that are associated with sparse crustal seismicity in the Seward Peninsula (Fig. 3). In many cases, the locations of earthquakes should match modern topographic lineaments; however, the discrepancies between the earthquake, topography, and fault data sets, consistent with the previously discussed errors in the digitized /topogrfy/vector/nor_pac contours, can cause apparent offsets. For example, the Kaltag fault (K in Fig. 3) plots ~5 km southeast of the Unalakleet River and associated topographic lineament where they and the fault enter Norton Sound, and the Togiak-Tikchik strand of the Denali fault (T in Fig. 3) plots ~5 km southeast of its associated topographic lineament and Togiak Lake, close to its entry into Bristol Bay near Hagemeister Island.

"Magnetic-Lithologic Correlation" example, /data/examples/mag_lith (Figure 4)

Table 5 lists the data sets that are superimposed in this view; the higher numbered layers above and partly concealing the lower numbered layers (Fig. 4). These coverages are chosen to exemplify the possible use of GIS databases to correlate different data sets, and then to use these correlations to interpret other areas. The correlation we seek to explore here is that of igneous rocks with magnetic anomalies. Although the relation is not ubiquitous, igneous rocks, particularly mafic and ultramafic varieties, generally have more magnetite and other magnetic minerals than sedimentary rocks, and so are associated with high magnetic anomalies. Although more-magnetic lithologies may be present at depth beneath sedimentary basins, their associated anomalies are dampened by the presence of the sedimentary rocks above them; below the mid-crust most rocks lose their magnetic signature due to temperatures being above the Curie limit of magnetization.

Layers 1, 2, 4, and 5 in this view are all magnetic coverages, displayed with data of higher quality and higher resolution toward the top of the stack of layers. The shallowest magnetic layers, 4 and 5, are the land coverages for Alaska and Russia, typically derived from dense flight-line coverage. The deeper layers, 1 and 2, have their lower-resolution land parts obscured by the upper layers, but provide coverage offshore that is typically less well sampled by sparse marine geophysical tracklines. Placing topographic contours (/topogrfy/vector/nor_pac) above the marine magnetic coverages, but below the land magnetic coverages, provides bathymetric contours that identify the location of the shelf edge, without obscuring or confusing the land areas on which the geology is overlain. Because both russ_mag and ak_mag obscure the coastlines and some nearshore bathymetry, the World Vector Shoreline is displayed as layer 8. Note that where offshore data were sampled along a single ship track, even though the information is strictly correct only along that line, the grids typically show data several grid cells wide, and so appear on our image as narrow bands of color-coded information rather than as lines (outer Bristol Bay and the northeast Pacific Ocean are areas where the magnetic information comes from sparse ship tracks). For all four magnetic coverages a dichromatic red-blue color scale is used (as for the gravity coverage in the "Active Earth" example). In order to visually match

TABLE 5. DATA SETS DISPLAYED IN "MAGNETIC-LITHOLOGIC CORRELATION" EXAMPLE

	Data set location	Legend location in /norpac/data/legends/mag_lith	Data description
9	cultural/latlong5	shorline.avl	Latitude and longitude grid
8	topogrfy/vector/shorline	shorline.avl	World Vector Shoreline
7	examples/rus_geol.shp	igneous.avl	Geologic map of Russia with igneous lithologies selected
6	examples/ak_geol.shp	igneous.avl	Geologic map of Alaska with igneous lithologies selected
5	magnetic/russ_mag	russ_mag.avl	Magnetic map of Russia
4	magnetic/ak_mag	ak_mag.avl	Magnetic map of Alaska (largely onshore)
3	topogrfy/vector/nor_pac	nor_pac.avl	Circum–North Pacific region (1:10 000 000)
2	magnetic/dnag_mag	dnag_mag.avl	Magnetic map of North America, onshore and offshore
1	magnetic/arct_mag	arct_mag.avl	Magnetic map of the Arctic (largely offshore)

the different coverages where they abut, because each magnetic coverage has a slightly different mean and range we have defined four different legends in which identical colors correspond to identical ranges of standard deviations away from the specific data mean.

In order to compare geology with magnetic data we need to display two areal coverages so that both are visible simultaneously. Hence the onland part of the geological map of Russia (polygons of /geology/onshore/rus_geol with attribute agecod ≤ 256) and the entire geological map of Alaska (/geology/onshore/ak_geol) are shown as transparent overlays over the magnetic grids. Because it is not possible to label individual geological units without further obscuring the magnetic display, we chose instead to highlight all igneous lithologies in yellow, and to shade gray all other lithologies. This example does not present well in norpac2.apr, for which Spatial Analyst is not available to provide the dichromatic red-blue color scale for the magnetic field. The Russian geology and Alaskan geology data sets are exported as shape files, then igneous units (intrusive, volcanic, and ophiolitic) were selected by Boolean query of the legends, and given the value "True" for the new polygon attribute (Igneous) in attribute files ak_geol.dbf and rus_geol.dbf. These igneous units are, on the Alaska map, any unit with its identifying attribute (mapunit_ab) containing the letter "i," except units identified as "Ice" (i.e., all intrusives), and any identifier containing the letter "v" (i.e., volcanics), or ending in the letter "u" (i.e., ultramafics, but avoiding abbreviations for time periods, "Upper ***"). On the Russia map, these are lithologic units that did not contain the label "acoustic" (corresponding to undifferentiated offshore acoustic basement) or the label "continential" (*sic*) (corresponding to platform deposits); all other units are labeled "False."

When the areas of igneous outcrop in the southern Brooks Ranges or in Chukotka are examined, this "Magnetic-Lithologic Correlation" example shows that igneous rocks in these regions correlate with high-spatial-frequency, high-intensity magnetic anomalies. In contrast, areas underlain by sedimentary rocks, such as the North Slope of Alaska, have quieter magnetic signatures. Can this correlation be taken offshore, into regions that are poorly mapped geologically? On the Bering Shelf the style of magnetic anomalies varies widely, and has been described both as showing a fairly simple pattern (low-high-low from north to south; Marlow et al., 1976), the high-anomaly zone marking a submarine, Late Cretaceous–early Tertiary volcanic belt (Worrall, 1991) and as a more complex pattern of magnetic domains interpretable as a pattern of accreted terranes (McGeary and Ben-Avraham, 1981), although the degree of sedimentary burial of the basement also contributes significantly to the observed magnetic signature. Thus Worrall (1991) identified as volcanics the zone from the Anadyr basin, including the Saint Matthew–Nunivak arch, that broadens eastward to include the Goodnews arch and much of Bristol Bay. McGeary and Ben-Avraham (1981) interpreted the same data in more detail, e.g., describing a small region of lower anomalies within the high-anomaly zone midway between Nunivak Island and the Pribilof Islands. Marlow et al. (1976) noted that the northern boundary of the region of high-amplitude, high-frequency magnetic anomalies is close to the southern boundary of the Saint Matthew basin–Hall basin, whereas the southern limit of the high-intensity magnetic belt generally is coincident with the northern boundaries of the large outer shelf basins such as Saint George and Navarin, raising the possibility that any magnetic-lithologic correlation in this region is inappropriate. A GIS database and display such as ours cannot resolve such uncertainties, but they can make it easier to understand the limits of the available data and to test the possibilities.

ASSOCIATED STUDIES

This GIS compilation on this CD-ROM is part of a project on the major mineral deposits, metallogenesis, and tectonics of the Russian Far East, Alaska, and the Canadian Cordillera. The project aims to provide critical information on bedrock geology and geophysics, tectonics, major metalliferous mineral resources, metallogenic patterns, and crustal origin and evolution of mineralizing systems for these regions. Published major companion studies for the project are: (1) a report on the metallogenesis of mainland Alaska and northeastern Russia (Nokleberg et al., 1993); (2) a tectonostratigraphic terrane map of the Circum-North Pacific at 1:5 000 000 scale with a detailed explanation of map units and stratigraphic columns (Nokleberg et al., 1994a); (3) a tectonostratigraphic terrane map of Alaska at 1:2 500 000 scale (Nokleberg et al., 1994b); (4) a summary terrane map of the Circum–North Pacific at 1:10 000 000 scale (Nokleberg et al., 1997a); (5) detailed tables of mineral deposits and placer districts for the Russian Far East, Alaska, and the Canadian Cordillera in paper format (Nokleberg et al., 1996) and in CD-ROM format (Nokleberg et al., 1997b); (6) a GIS presentation of a summary terrane map, mineral deposit maps, and metallogenic belt maps of the Russian Far East, Alaska, and the Canadian Cordillera (Nokleberg et al., 1998); and (7) a study of the Phanerozoic tectonic evolution of the Circum–North Pacific (Nokleberg et al., 2000).

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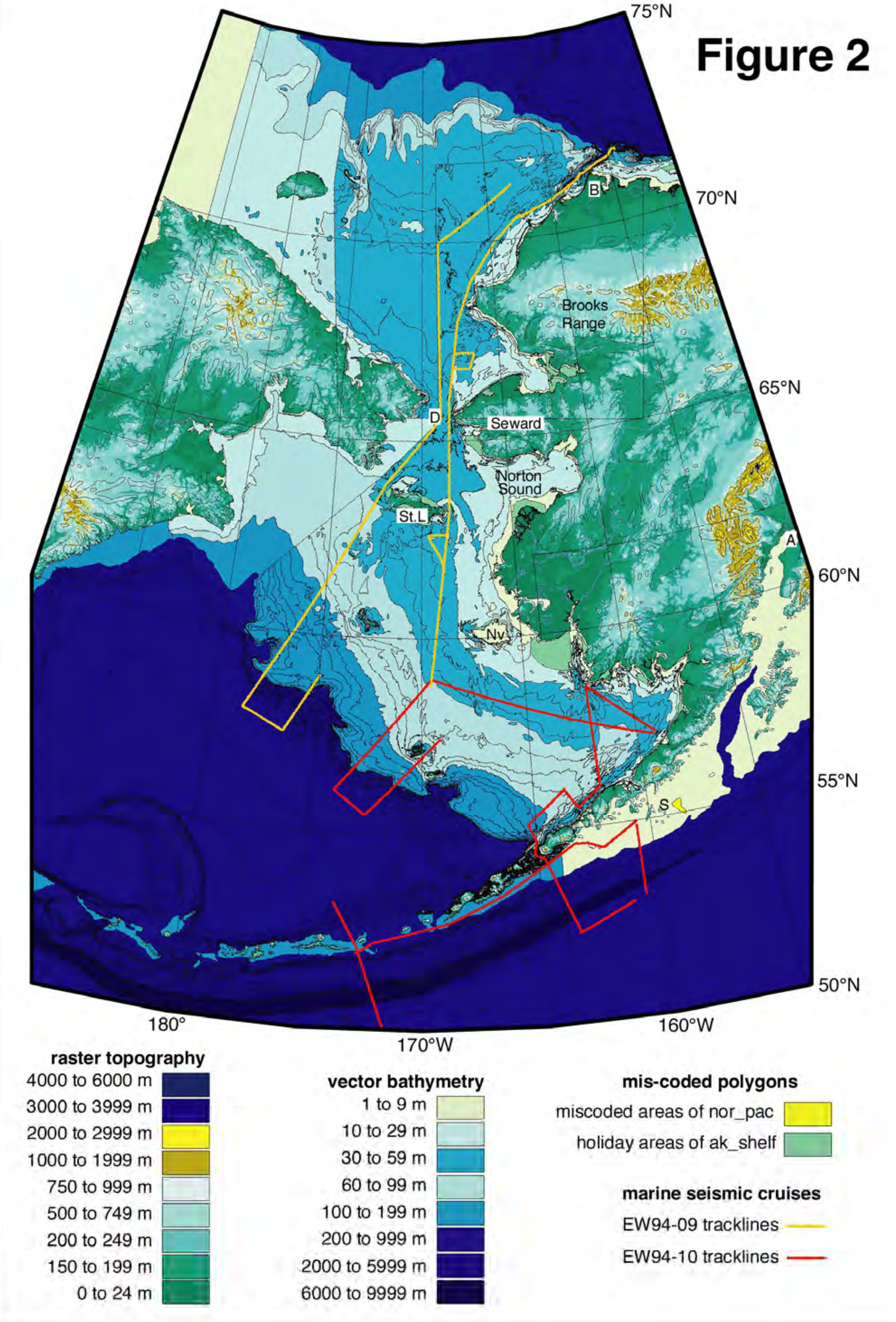

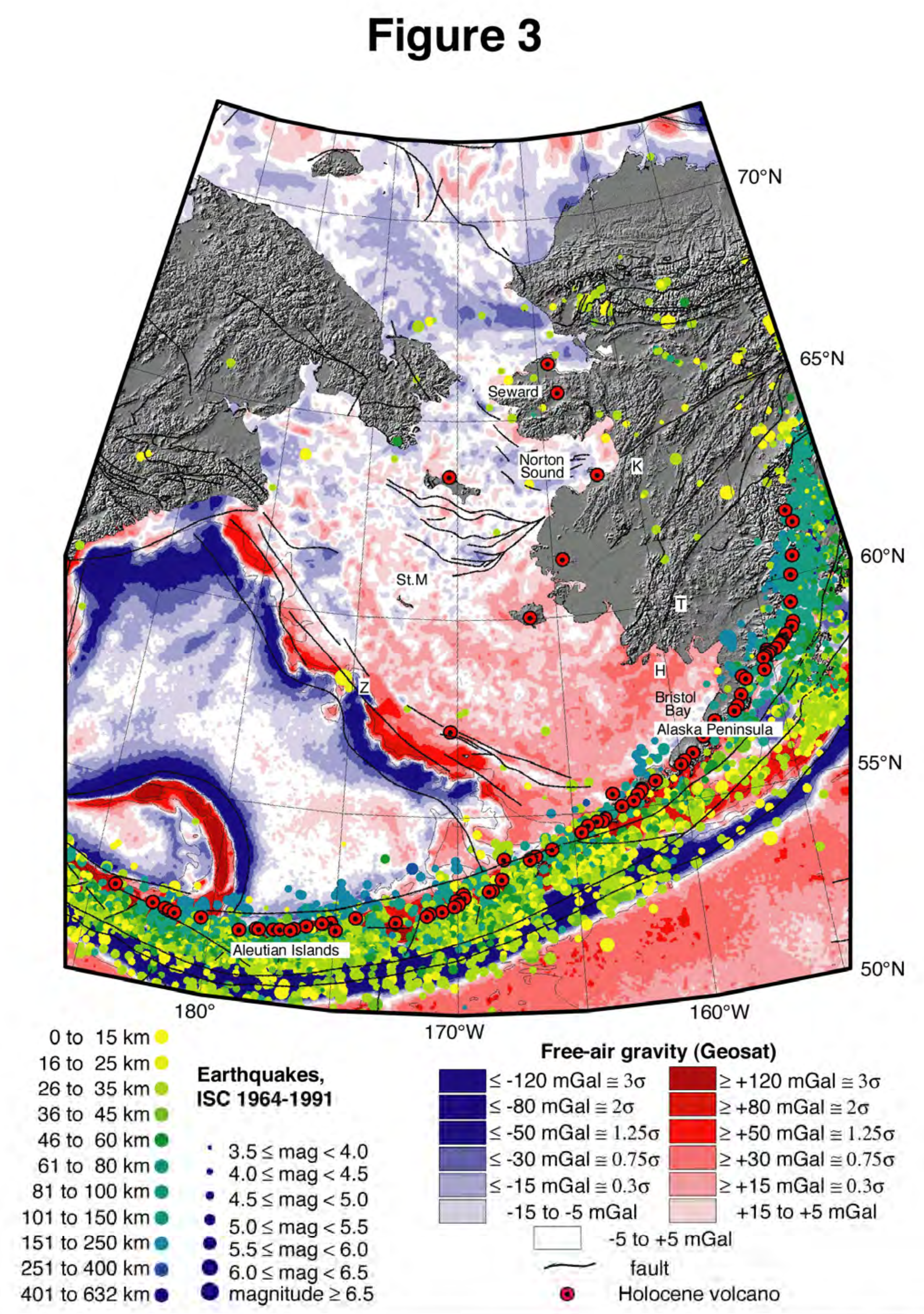

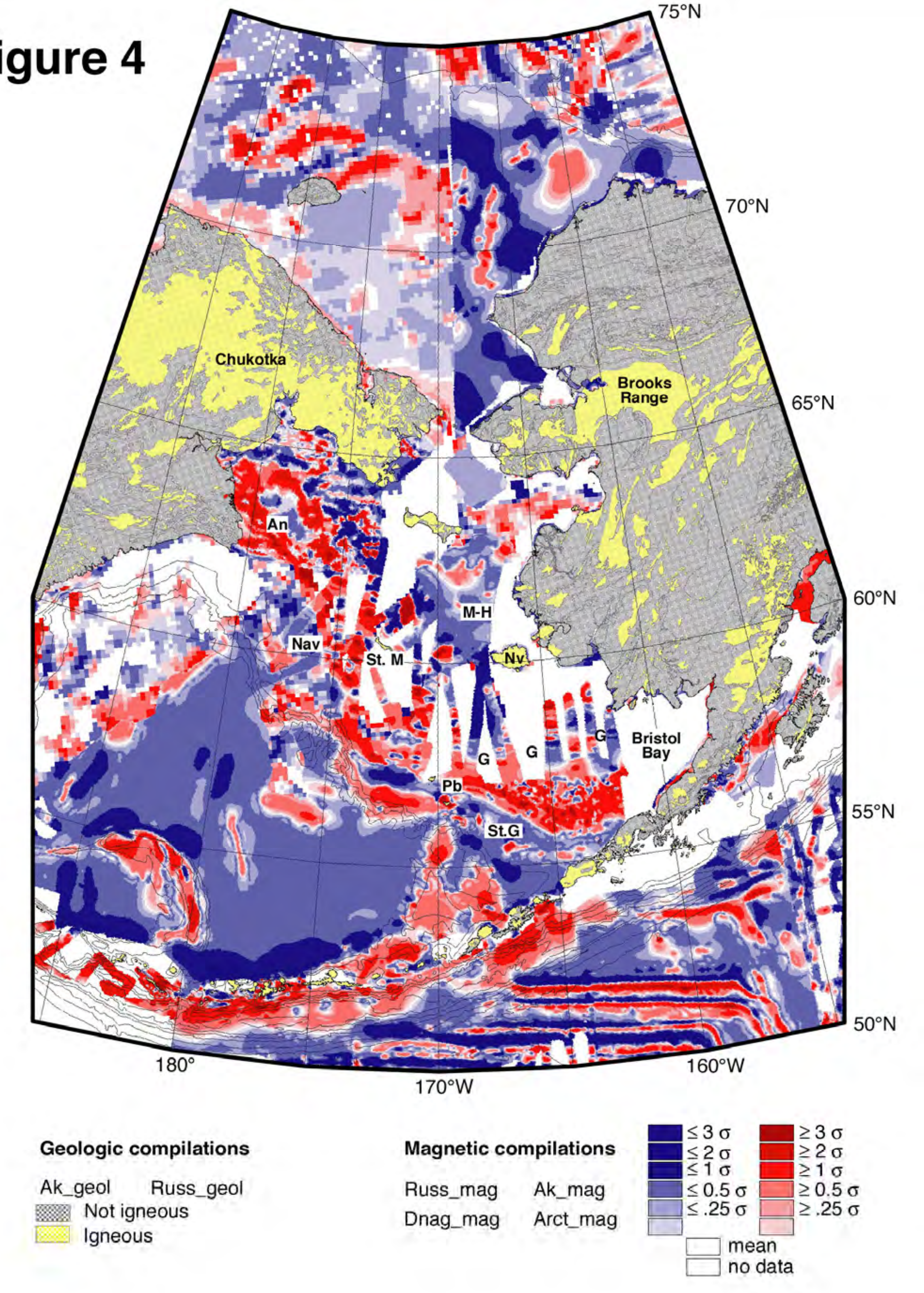

Figure 2 Topography of the Bering Shelf-Chukchi Sea and adjacent landmasses superimposed with tracklines of geophysical cruises discussed by Klemperer and others (this vol.). A = Anchorage; B = Barrow; D = Diomede Islands; Nv = Nunivak Island; S = Shumagin Islands; St.L = St. Lawrence Island. Image is on CD-ROM at /norpac/data/examples/topog_ex

Figure 3 Free-air gravity of the Bering Shelf-Chukchi Sea and relief of adjacent landmasses (sun-shaded with a sun-angle of 45° elevation from the northwest) superimposed with earthquake locations, Holocene volcanoes and faults. H = Hagemeister Island; K = Kaltag Fault; St.M = St. Matthew Island; T = Togiak-Tikchik strand of the Denali Fault and Togiak Lake; Z = Zemchug Canyon. Image is on CD-ROM at /norpac/data/examples/act_erth

Figure 4 Magnetic anomalies of the Bering Shelf-Chukchi Sea and adjacent landmasses superimposed with outline geological maps of Russia and Alaska. Igneous (volcanic, plutonic, ultramafic) units are tinted yellow. An = Anadyr Basin; G = Goodnews Arch; M-H = Matthew-Hall Basin; Nav = Navarin Basin; Nv = Nunivak Island; Pb = Pribilof Islands; St.G = St. George Basin; St.M = St. Matthew Island. The corresponding image on the CD-ROM at /norpac/data/examples/mag_lith has the additional feature that the grey and yellow shading, distinguishing igneous and non-igneous rocks, is transparent, allowing correlation of magnetic features from onshore to offshore.

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Figures 2, 3, 4 GIS compilations

Chapter 19, *Geographic Information Systems (GIS) compilation of geophysical, geologic and tectonic data for the Bering Shelf, Chukchi Sea, Arctic Margin and adjacent landmasses,*
by S. L. Klemperer, M. L. Greninger, and W. J. Nokleberg